Technical Report 166

EVALUATION OF INTERFERENCE SUPPRESSION OF FLUORESCENT LAMPS

6 October 1961

U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

EVALUATION OF INTERFERENCE SUPPRESSION OF FLUORESCENT LAMPS

Y-F006-09-202

Type C   Final Report

by

D. B. Clark

OBJECT OF TASK

To develop, or obtain commercially, fluorescent light fixtures that will suppress the inherent electromagnetic interference to levels below Navy specifications limits.

ABSTRACT

The evaluation of the interference characteristics of commercial fluorescent fixtures advertised as "interference-free," including both hot-cathode and cold-cathode lamps, demonstrates that those fixtures which are completely enclosed electrically are free of interference. A hot-cathode instant-start fixture, with conducting-glass door panel, interchangeable with an aluminum honeycomb door panel covering a one-piece metal fixture proved to be greater than 6 decibels below the specification limits shown in BuShips MIL-I-16910(A). The cold-cathode lamps tested failed to meet specification limits.

An enclosed fixture which failed to pass specification tests was modified by electrically bonding at all junctures at approximately 2-inch intervals, including the 2-inch by 2-inch by 1-3/8-inch-deep grill. By this means interference was reduced to an acceptable level.

Light emission from the interference-free commercial fixture was measured, and the conducting-glass panel and the honeycomb aluminum panel caused a loss of approximately 10 percent. Replacement of the nonconducting panel-closure gaskets provided by the manufacturer with this fixture, with radio-frequency-suppressing gasket stripping, resulted in an average reduction of 7 decibels in the magnetic induction field as measured with the loop antenna and the AN/URM-6 Receiver.

BACKGROUND

The fluorescent lamp has been a known source of radio interference for some time. The development of successful suppression of this interference has followed essentially two lines of approach, shielding and filtering. To suppress interference to levels below those required by military specifications has required the use of both filtering and shielding.

Reactive filter components, in the form of capacitors and inductors, have been used for some time in suppressing radio interference from fluorescent lamps. The simplest of these, although not the most convenient for tube life and filter installation, is a capacitor placed directly parallel to the lamp bulb. Capacitance values of approximately .05 microfarads are used for this purpose. Another common practice is to use a 3-section delta-connected capacitor across the line and to ground in the fixture. For more effective control, an inductive-capacitive line filter is used in each supply lead.

The shielding approach has progressed to the point where the fluorescent fixture is an integral-bonded metal shield, totally enclosing the lamps, with the light emerging through a panel with a transparent conductive coating on glass, or a honeycomb or cellular construction of metal such as aluminum.

This evolution of more and more shielding and filtering seems reasonable when we consider the actual nature of the noise source.[1] The fluorescent lamp is basically a mercury gaseous-discharge column which is reignited and extinguished 120 times per second in its operations from 60-cycle alternating current. The main sources of the electrical noise are at the ends of this column where the current enters or leaves by means of the cathode and anode in a concentrated arc or plasma. At these points, the high electrical field gradients are building up and collapsing, and ion plasmas are oscillating to produce radio frequency energies which can be disseminated by the following mechanisms:

1. Direct radiation from the source.

2. Radiation using the electrical-supply wiring and fixture as an antenna.

3. Conducted interference through the service lines.

4. Induced fields due to capacitive or magnetic coupling from the fixture and its associated wiring and grounding.

The development of the cold-cathode fluorescent lamp, which has no heated filament, was expected to reduce the noise-generating sources in the fluorescent lamp. This lamp is inherently less noisy than the hot-cathode lamps, but successive evaluations of this type of fluorescent lamp, at this Laboratory[2] and others,[3] have shown that without effective filtering and shielding cold-cathode lamps fail to meet military interference requirements. Its failure is blamed by some on asymmetries in its cathode construction and on early gassing as a result of reduction or flaking off of the emitter material provided on the cathodes.

Recent attempts by the author to reduce the inherent noise-producing characteristics of the hot-cathode fluorescent lamp by means of filament designs which will spread the cathode arc and reduce the ion density at this point have shown some success.

INTRODUCTION

Measurements of conducted and radiated interference from the four fluorescent fixtures tested (Figures 1 through 5) were made according to MIL-I-16910(A) (BuShips) specifications. The frequency range was from 14 kilocycles to 1,000 megacycles.[4] Conducted and radiated intensities were measured at a distributed number of frequency points, as indicated in the accompanying graphs. In addition, the full spectrum from 14 kc to 1,000 mc was monitored for any significant intensities at other frequency points. When identifiable sources, such as broadcast stations, were encountered, they were not included.

The interference meters used, and their corresponding frequency ranges, are shown in Table I.

Table I. Interference Meters Used

Frequency in Megacycles	Interference Meter
.014 to .150	AN/URM-6
.150 to 20	AN/PRM-1
20 to 400	AN/URM-7
400 to 1,000	AN/URM-17

DESCRIPTION OF FIXTURE A

The first fixture, A, was a 48-inch, four-lamp hot-cathode fluorescent fixture made up at the Laboratory from a commercial unit which had previously housed cold-cathode lamps and had failed to meet military specification limits for interference (Figure 1). The fixture housing was modified by electrical bonding of all joints and closures, and an inductive-capacitive line filter was installed in the supply leads inside the fixture. The modifications were made in order to verify the principle of total electrical enclosure. Measurements of both the conducted and the electrical field component of the radiated interference were made according to specifications.[4] The radiated measurements were made in a screen room with the rod and dipole antennas placed 3 feet from the fluorescent fixture. Measurements were made with the 2-inch-square by 1-3/8-inch-deep grill removed, and then with the grill bonded in place.

Special 5-inch-long copper sleeves, with diameters equal to the outer diameter of the lamp, were placed over the ends of each lamp tube and grounded to the fixture by phosphor-bronze clamps. These were used in an attempt to prevent the noise generated at the ends of the tubes from emerging from the shield through a "wave-guide below cut-off" effect. Measurements of radiated interference were then made, with the grill bonded in place, and compared to measurements made without the special sleeves. The effect of the grill on the direct light output of the fixture was measured.

RESULTS WITH FIXTURE A

Measurements of conducted interference are shown in Figure 6 in comparison to the specification limit line. In addition, the receiver and external ambient noise level is recorded with the fluorescent light turned off at each frequency point of measurement. No measurable interference, above the ambient of the receiver, was encountered.

The measurements of radiated interference are shown in Figure 7 in comparison with the specification limit line and the ambient noise level with the grill bonded in place, and removed.

The effect of the copper sleeves on the radiated interference level of fixture A, in the frequency range 20 to 140 kc, is shown in Table II, to give an average of 5.25 db of increased attenuation over that provided by the fixture. Noise levels from the fixture at the higher frequencies were insufficiently greater than the receiver noise level and ambient background to assess the effect of the copper sleeves in this region. No measurable reduction in light output due to the grill was observed (Table III).

Table II. Effect of 5-Inch Copper Sleeves on Each End of the Fluorescent Tubes in Fixture A - Grill in Place

Frequency (mc)	Reading Without 5-Inch Shields ($\mu v/m/kc$)	Reading With 5-Inch Shields ($\mu v/m/kc$)	Attenuation Due to Shields (db)
.02	28.5	19	3.5
.025	70	20.5	10.7
.05	17	11	3.8
.06	10.5	5.2	6.1
.08	6.6	6	.8
.10	4.6	2.15	6.6
			avg. 5.25

Table III. Light Transmission of Fixtures

Fixture	Light Intensity (foot candles)	Transmission (percent)
B, no grill	148	100
B, glass grill	133	90
B, honeycomb aluminum grill	135	91
A, no grill	180	100
A, with 2 sq. inch by 1-3/8-inch-deep grill	180	100

CONCLUSIONS ON FIXTURE A

1. A fluorescent fixture with integral electrical bonding and with a line filter inserted, can contain and attenuate the interference from hot-cathode fluorescent lamps to meet specification limits.

2. Conducting sleeves placed over the ends of fluorescent lamp tubes and grounded to the fixture can cause a reduction in interference by a factor of about 2 (6 db) in the region of highest interference.

DESCRIPTION OF FIXTURE B

Fixture B was also a 48-inch hot-cathode fluorescent lamp, but with only three lamps. This commercial fixture also contains an inductive-capacitive line filter inside the unit; a radio frequency shield encloses the fluorescent lamps, ballast, and associated wiring. Included with this fixture are two interchangeable door panels. One is a conductive coated glass (Figure 2), and the other is a honeycomb aluminum foil panel (Figure 3). The radiated electrical field component and the conducted interference were measured according to specifications,[4] in a screen room. The lamps were extinguished after each measurement of interference for a reading of the ambient interference. Radiated measurements were made with the rod and dipole antennas at 3 feet from the fixture, with the fixture doors in place, and with doors removed.

The door panels as received from the manufacturer, had a nonconducting asbestos gasket forming the panel-door closures. This was replaced by a radio-frequency-attenuating, conductive gasket material, and its effect on the interference measurements was recorded. Paint was removed and a conductive coating was applied to the fixture on the edges which met with the door panels. See Figure 3.

Measurement of the magnetic field component was made by using loop antennas, with the AN/URM-6 and AN/PRM-1 interference meters. This loop measurement was made at 3 feet and at 4 feet from the fixture to determine the relationship of the readings to distance from the source. The effects of the honeycomb aluminum and glass panels on the direct-light output of the fixture was measured.

RESULTS WITH FIXTURE B

Measurements of conducted interference are shown, in Figure 8 and 9, in comparison to a line 6 db below the specification limit line and to the ambient noise level. No measurable component of interference was found.

The measurements of radiated interference which exceed the ambient noise, shown in Figure 10 and 11, are more than 6 db less than the level of the specification limit line, for the two types of door panels in place. No measurable interference was found with either door panel in place, but considerable noise was evident with the panels removed as shown in Figure 12.

Magnetic interference measurements made with the loop pickups were not presented as radiated interference, but presumed to represent induction field components. The absence of corresponding measurable electrical field components and a greater than $1/D^2$ decrease of the magnetic component measured with the distance D as shown in Table IV are the indications which point to a near field induction component for the measurements made with the loop. Ambient and receiver noises exceeded measurable magnetic field components for all loop measurements other than those made with the AN/URM-6.

The addition of the RF gasket material to the glass and aluminum panels of fixture B reduced the magnetic field measurements made with the AN/URM-6 by an average of approximately 7 db (see Table V). Since the electric field from fixture B, as delivered by the manufacturer, was too low to measure throughout the entire frequency range of 14 kc to 1,000 mc, no comparison could be made with the RF gaskets added.

Light intensities were measured, directly below the fixtures, with a Weston illumination meter, Model 756, at a vertical distance of 3 feet. These intensities are shown in Table III, for the two fixtures A and B, with the grills in place, and with grills removed.

CONCLUSIONS ON FIXTURE B

1. A hot-cathode fluorescent lamp fixture is commercially available which will reduce interference levels more than 6 db lower than limits expressed in military specifications.[4]

2. The magnetic field component of the induction near field of the fixture can be reduced by about half (6 db) by the substitution of RF gasket material for the nonconducting gasket supplied by the manufacturer.

3. Light illumination from this fixture is reduced by about 10 percent by either the glass or honeycomb aluminum door panels.

Table IV. Magnetic Field Loop Measurements Taken at 3-Foot and 4-Foot Distances From the Fluorescent Fixture

Frequency (mc)	I_4 (μv)	I_3 (μv)	$\frac{I_3}{I_4}$	Exponent of Distance
.02	2,000	4,200	2.1	
.025	1,800	3,750	2.08	
.03	1,100	2,750	2.5	
.05	700	1,400	2.0	
		avg.	2.17	$D^{2.7}$

Table V. Effect of RF Door Panel Gasket on Indicated Magnetic Field Measurements of Fixture B, Using the AN/URM-6 Receiver with Loop

Panel	Frequency (mc)	Indicated Reading in μv		Attenuation Due to RF Gasket (db)
		without RF gasket	with RF gasket	
Cond. Glass	.02	8.8	3.16	8.9
" "	.025	8.4	4.02	6.4
" "	.03	9.6	2.48	11.7
" "	.05	4.6	2.37	5.8
" "	.06	2.86	1.35	6.5
				avg 7.86
Honeycomb Aluminum	.02	6.55	4.15	4.0
"	.025	7.25	2.74	8.4
"	.03	5.66	2.64	6.6
"	.05	3.0	2.32	2.3
"	.06	2.8	1.26	6.9
				avg 5.64
				grand avg 6.75

DESCRIPTION OF FIXTURES C AND D

Fixture C was a commercial cold-cathode, 24-inch, two-light, fluorescent desk lamp, Figure 4. Fixture D was a large 8-foot, four-lamp, industrial explosion-proof cold-cathode unit, Figure 5. Both of these units were advertised by the manufacturer as interference-free fixtures Measurements of radiated and conducted interference were made in accordance with the requirements of specifications.[4] The radiated measurements were made in a screen room with the rod and dipole antennas placed 3 feet from the fixture.

RESULTS WITH FIXTURES C AND D

Measurements of conducted interference are shown in Figure 13 and 14, and compared to the specification limit line and the ambient noise level. Conducted interference levels of both fixtures C and D were below those required in the military specifications.

Measurements of radiated interference for C and D are shown in Figures 15 and 16. The radiated interference from both fixtures exceeds specification limits over most of the frequency range of measurement.

CONCLUSIONS ON FIXTURES C AND D

1. Fixture C and D, cold-cathode fluorescent lamps, do not meet the specification requirements for radiated interference.

2. Fixture C and D do meet the specification requirements for conducted interference. In actual application, this latter property might allow the usefulness of these fixtures in a sensitive laboratory if the fixture itself is not in close proximity to any sensitive equipment.

RECOMMENDATIONS

For applications of fluorescent lamps, where it is desirable to meet military specifications for radiated and conducted interference, it is recommended that lamp fixtures be chosen which demonstrate a combination of total electrical enclosure and internal filtering, as for fixtures A and B, in addition to manufacturer's claims of "freedom from interference."

Future efforts in the development of interference suppression for fluorescent lamps should be aimed towards reduction of the sources in the lamp tubes themselves.

REFERENCES

1. C. Matsuda, et al. "On the Radio Noises and Oscillations Caused by Fluorescent Lamps." Memoirs of the Faculty of Engineering, Kyoto University, Vol. XIX, No. 1, April 1957, p. 25.

2. NCEL. Technical Note 301, Radio Interference Evaluation of Cold-Cathode Fluorescent Lighting Installations, by H. M. Shroyer and D. B. Wright. Port Hueneme, California, 16 April 1957.

3. Bureau of Ships. NAVSHIPS 93545, Study of Radio Interference from Fluorescent Lamps, 1 January 1960.

4. Bureau of Ships, Specification MIL-I-16910(A), Interference Measurement, Radio Methods and Limits, 30 August 1954.

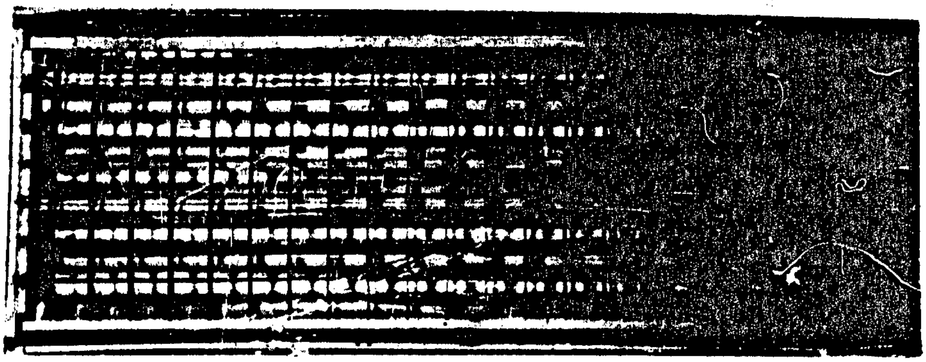

Figure 1. Fixture A, electrically bonded.

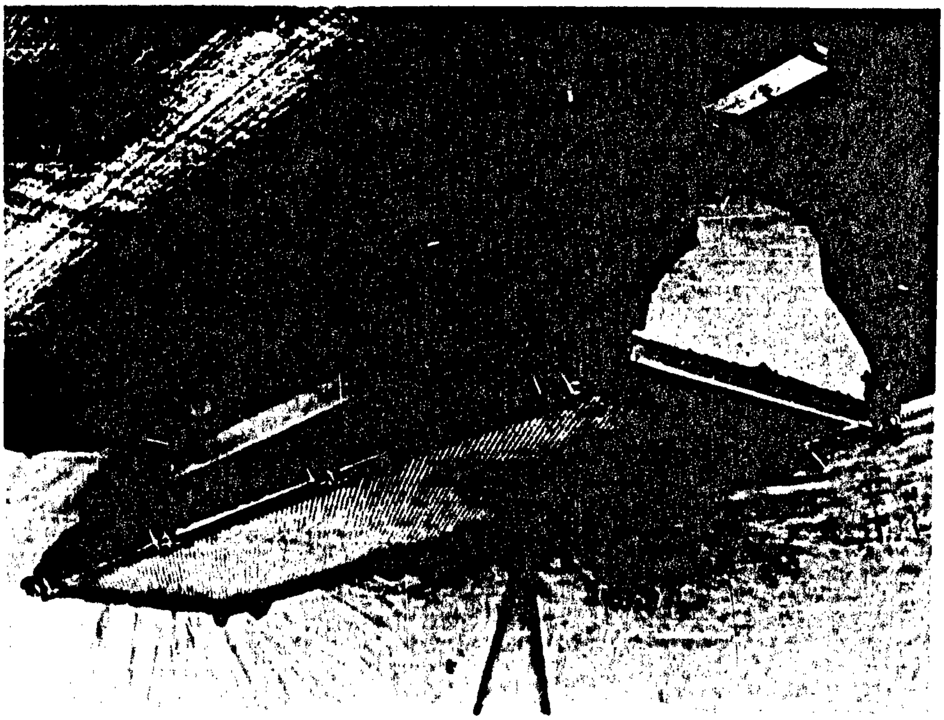

Figure 2. Fixture B, with conducting glass door panel.

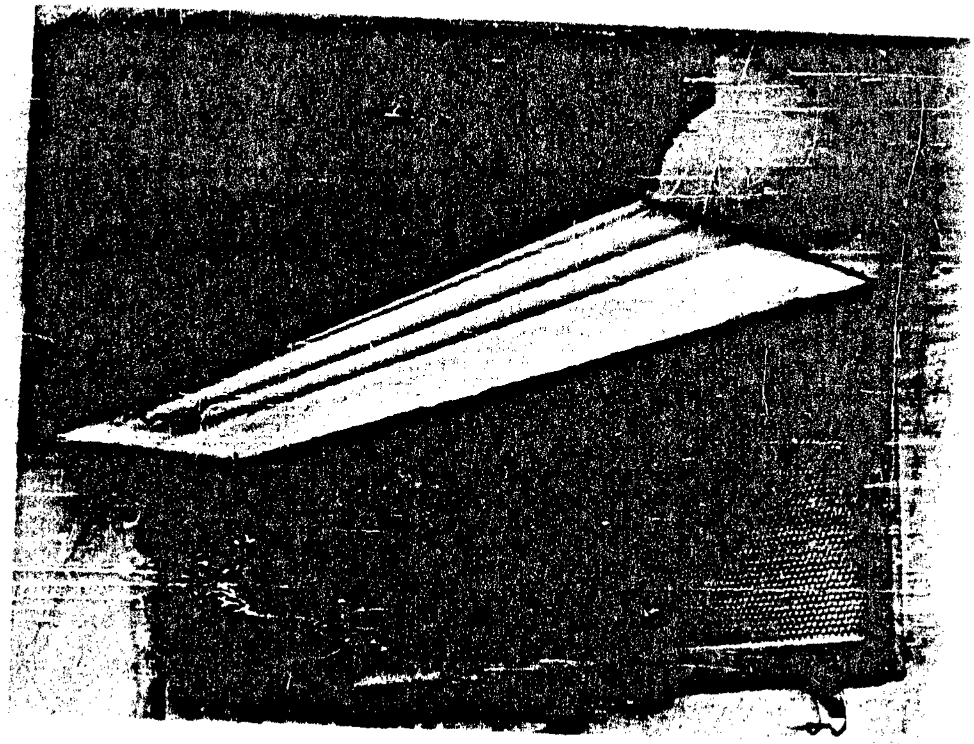

Figure 3. Fixture B, with honeycomb aluminum door panel and and RF gasket.

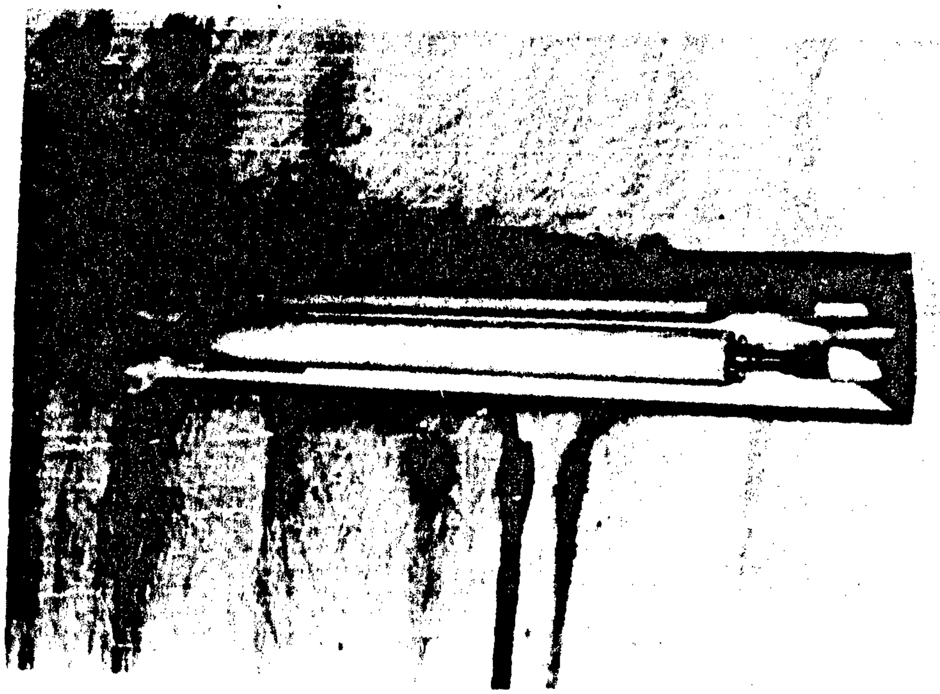

Figure 4. Fixture C, cold cathode desk lamp.

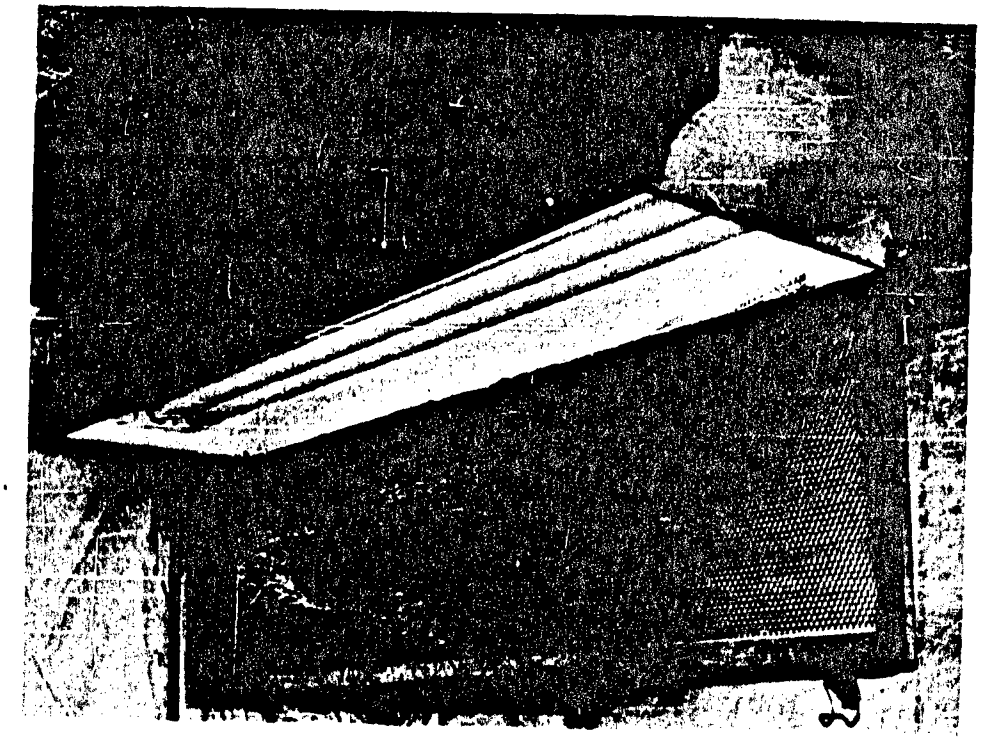

Figure 3. Fixture B, with honeycomb aluminum door panel and and RF gasket.

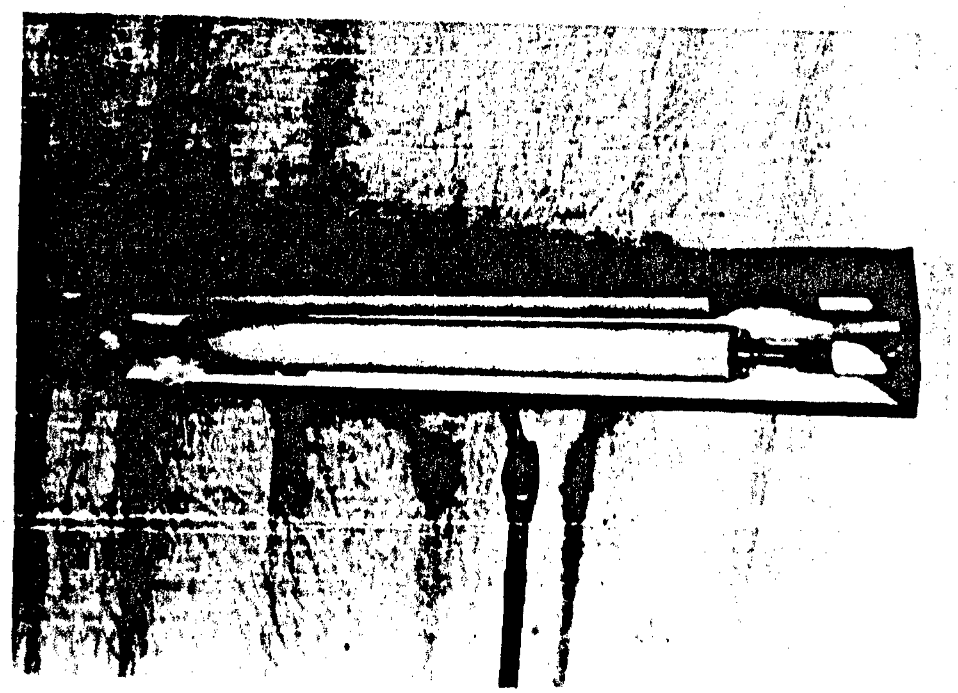

Figure 4. Fixture C, cold cathode desk lamp.

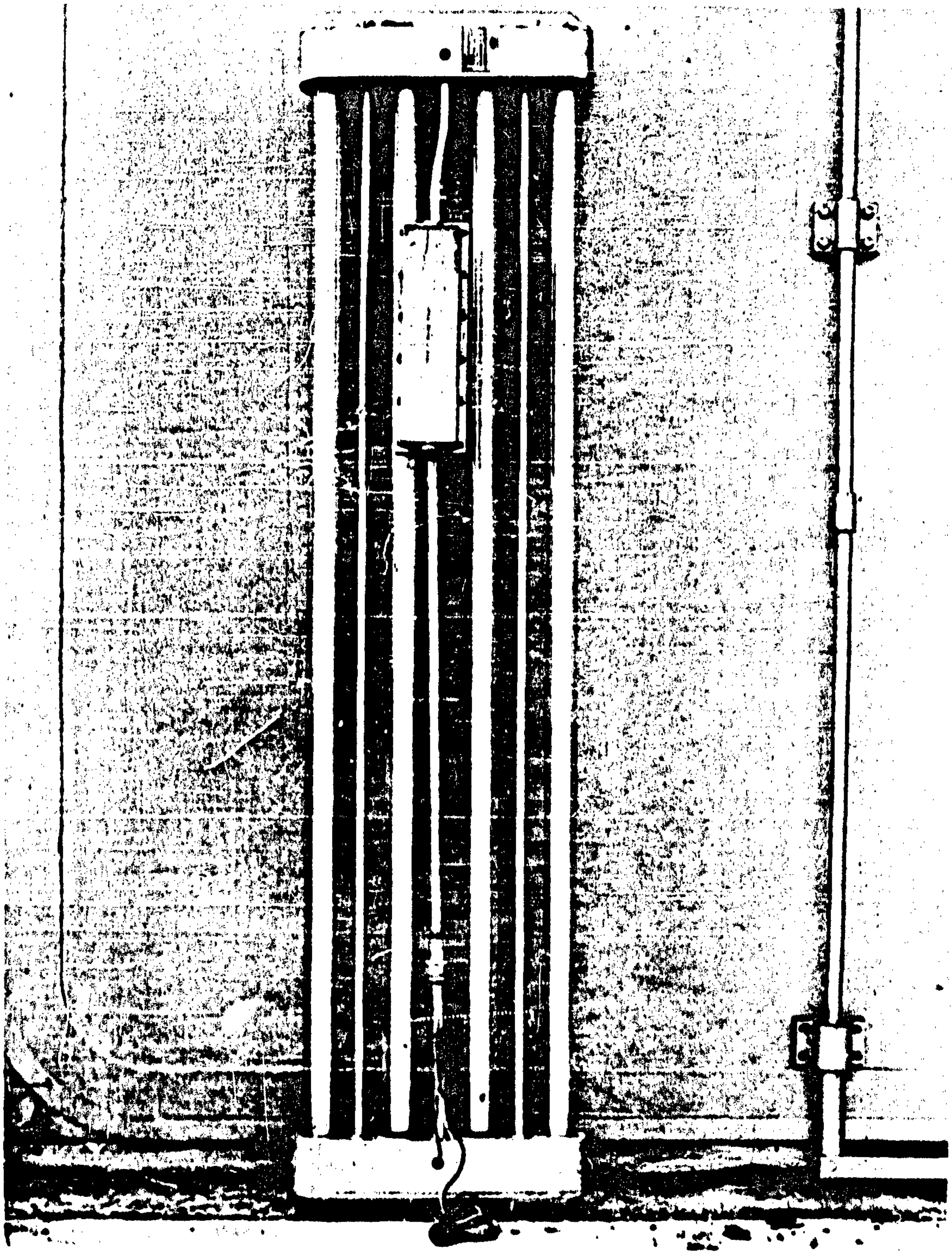

Figure 5. Fixture D, cold cathode industrial lamp.

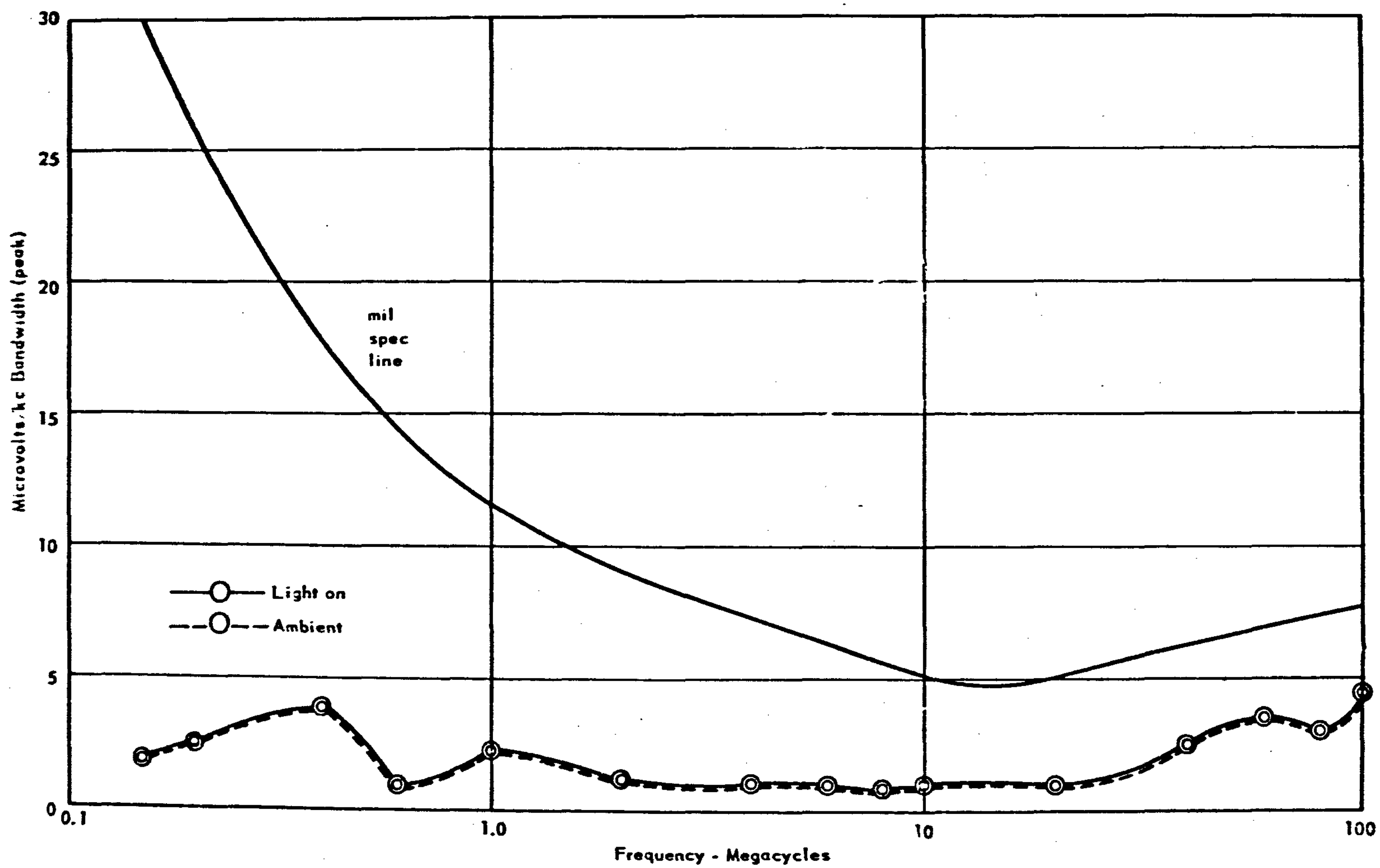

Figure 6. Fixture A, broadband conducted interference (peak).

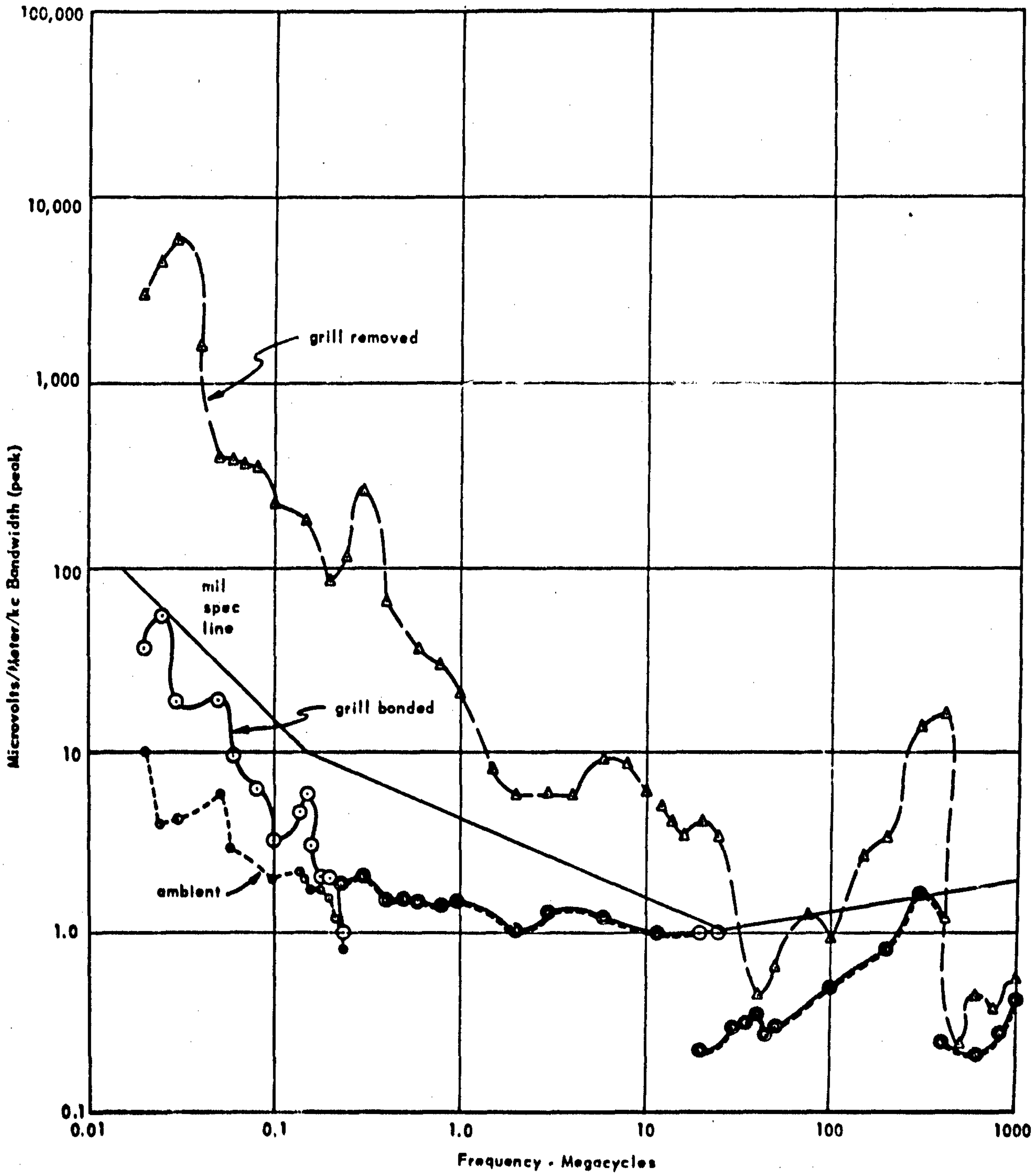

Figure 7. Fixture A, broadband radiated interference (peak).

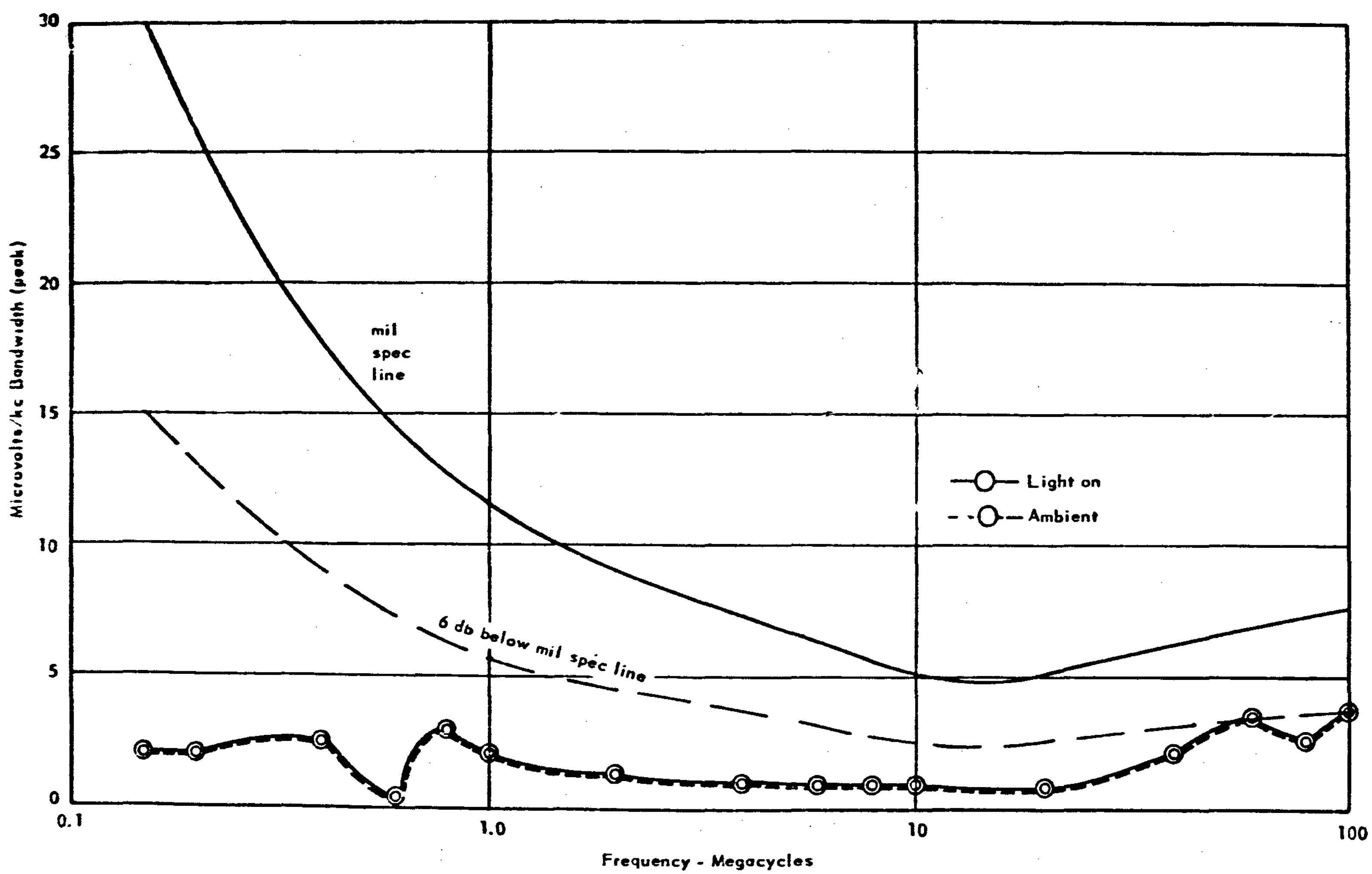

Figure 8. Fixture B, glass grill, broadband conducted interference (peak).

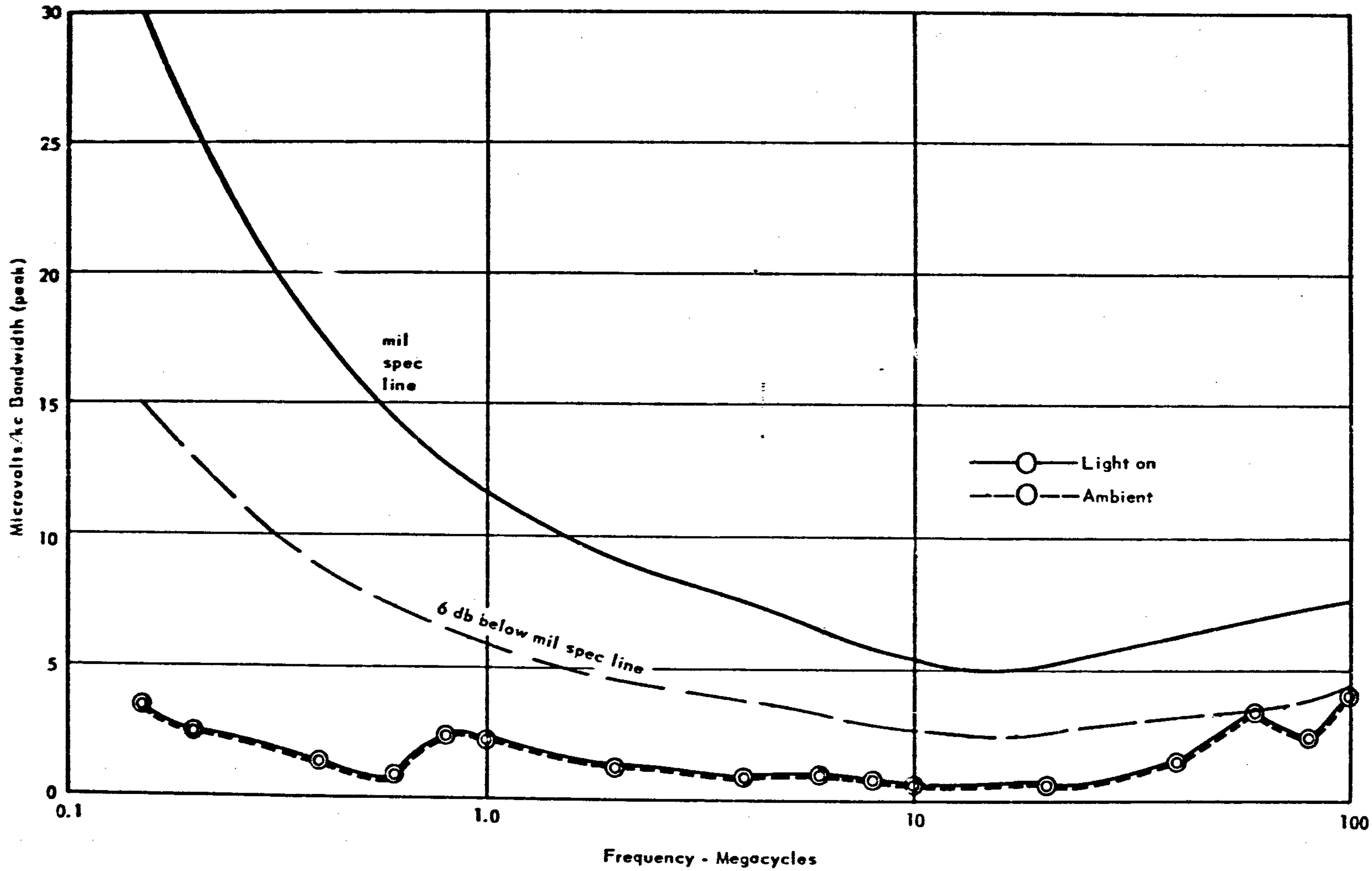

Figure 9. Fixture B, honeycomb aluminum grill, broadband conducted interference (peak).

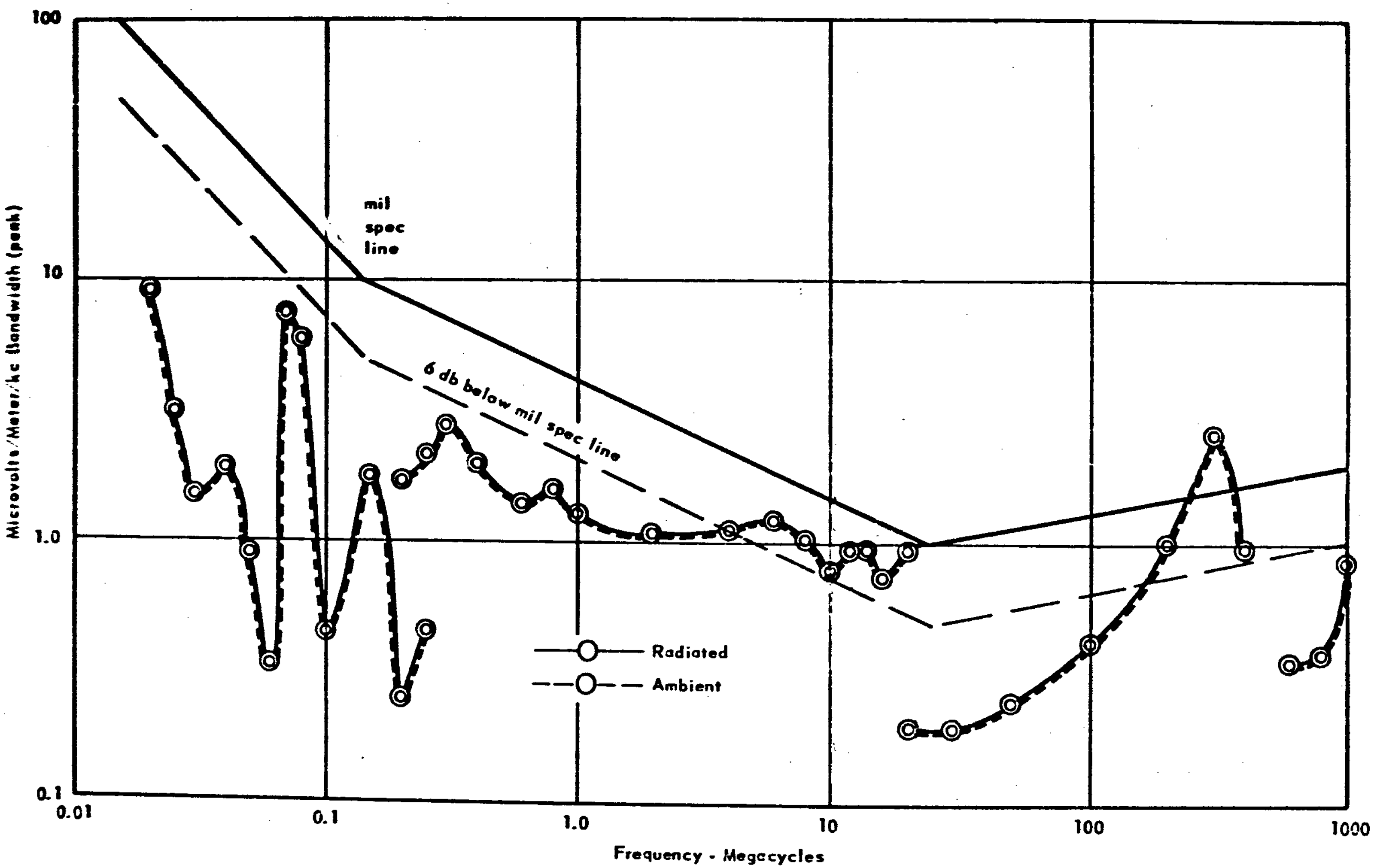

Figure 10. Fixture B, glass grill, broadband radiated interference (peak).

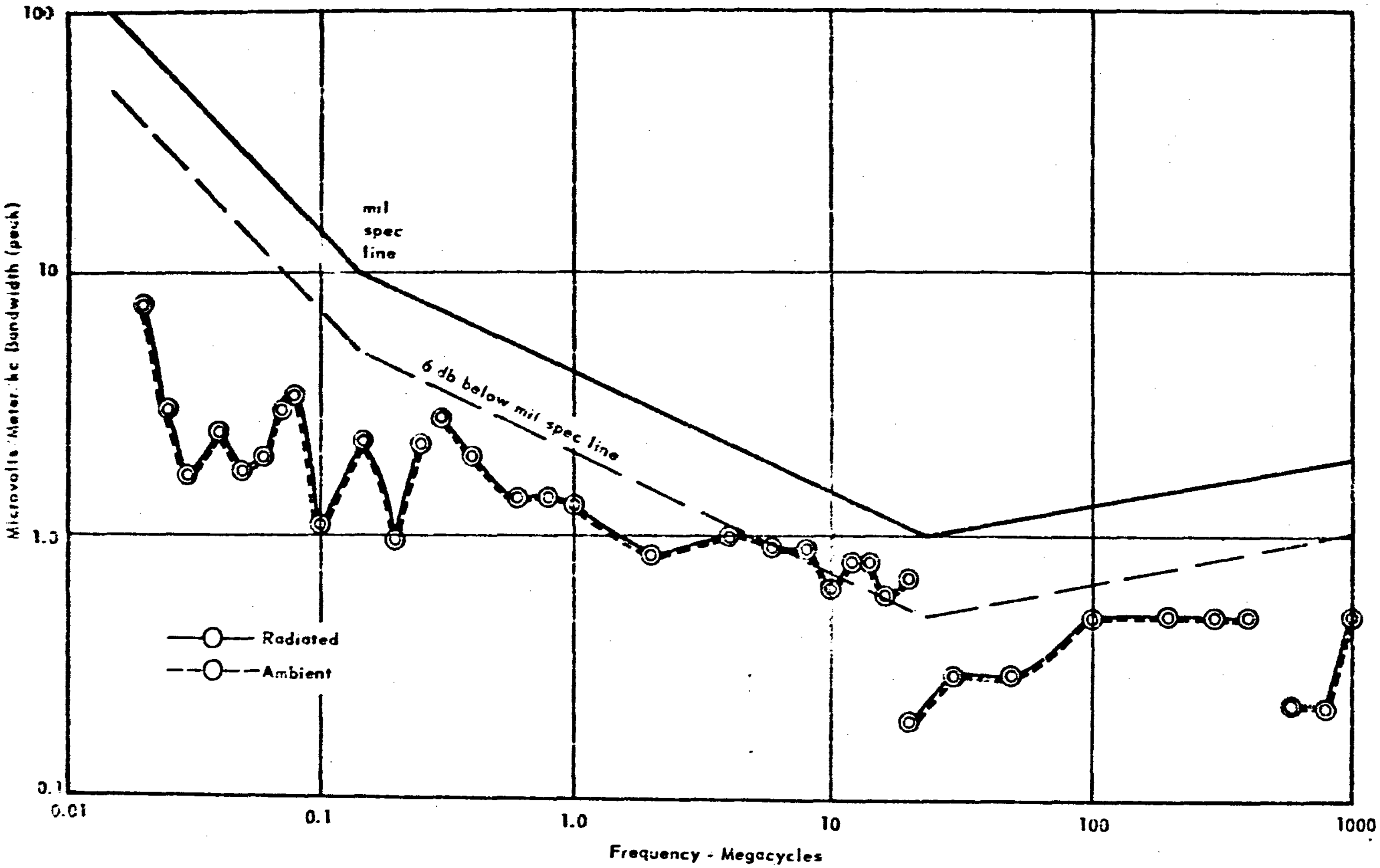

Figure 11. Fixture B, honeycomb aluminum grill, broadband radiated interference (peak).

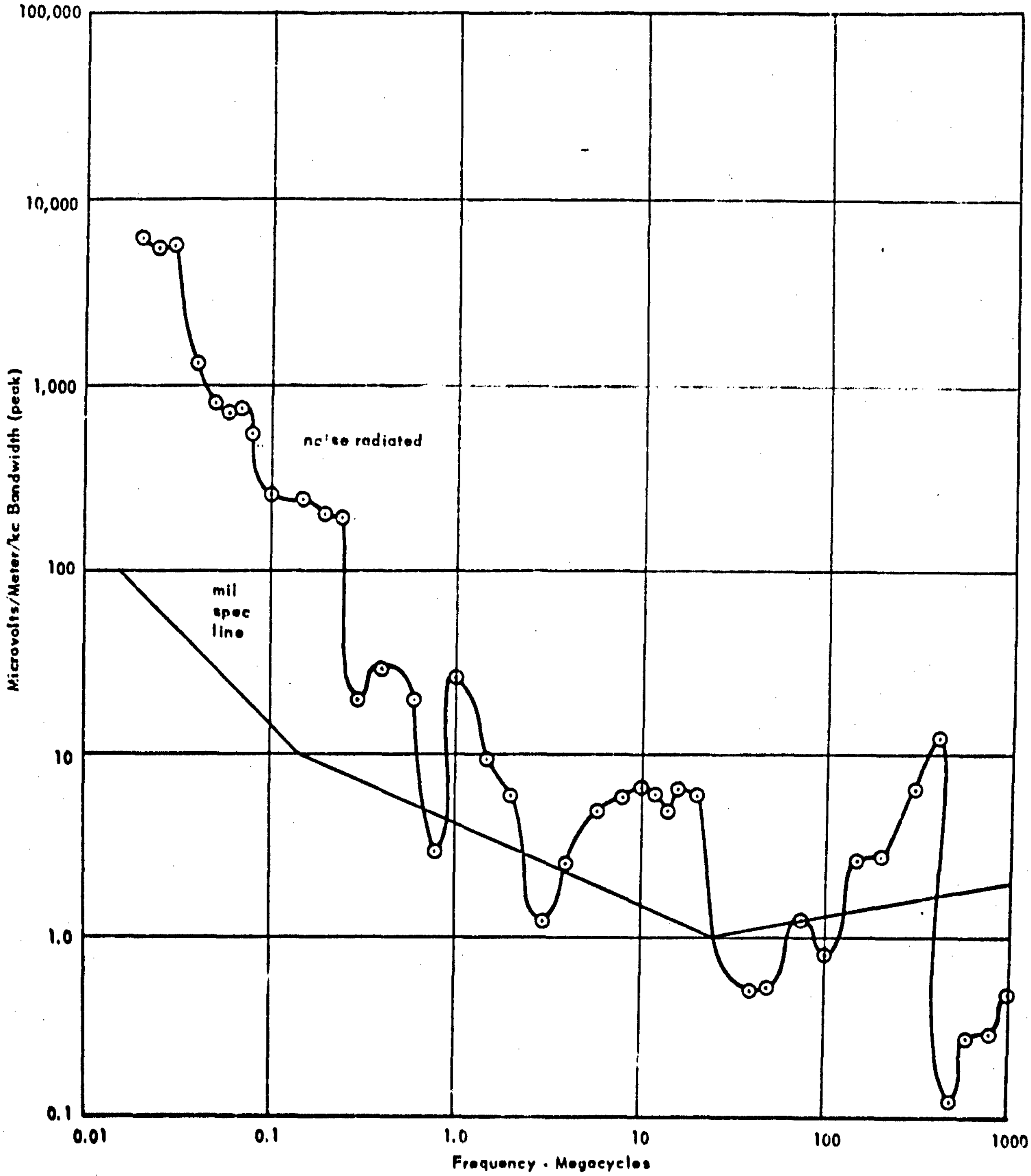

Figure 12. Fixture B, grill removed, broadband radiated interference (peak).

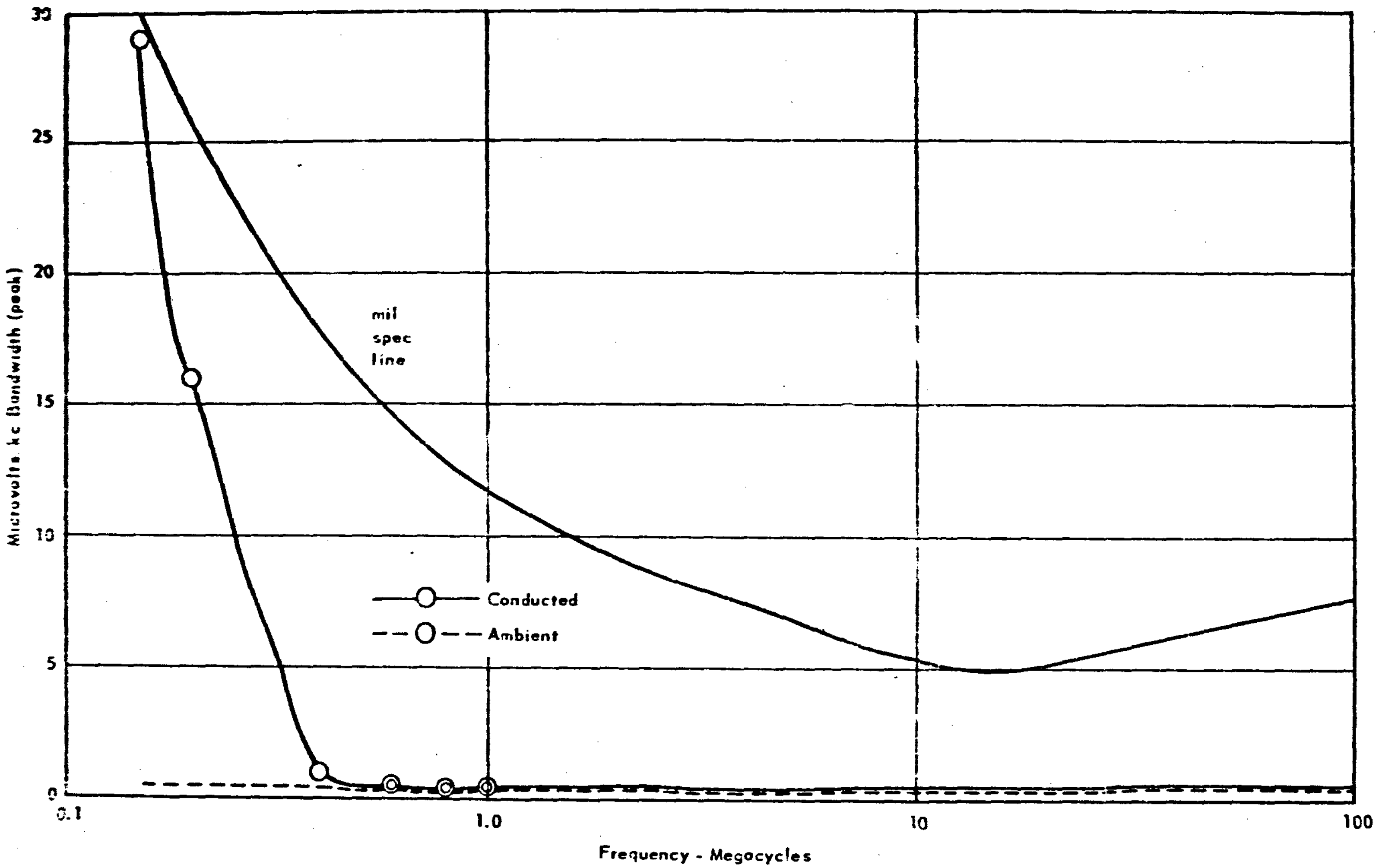

Figure 13. Fixture C, cold cathode desk lamp, broadband conducted interference (peak).

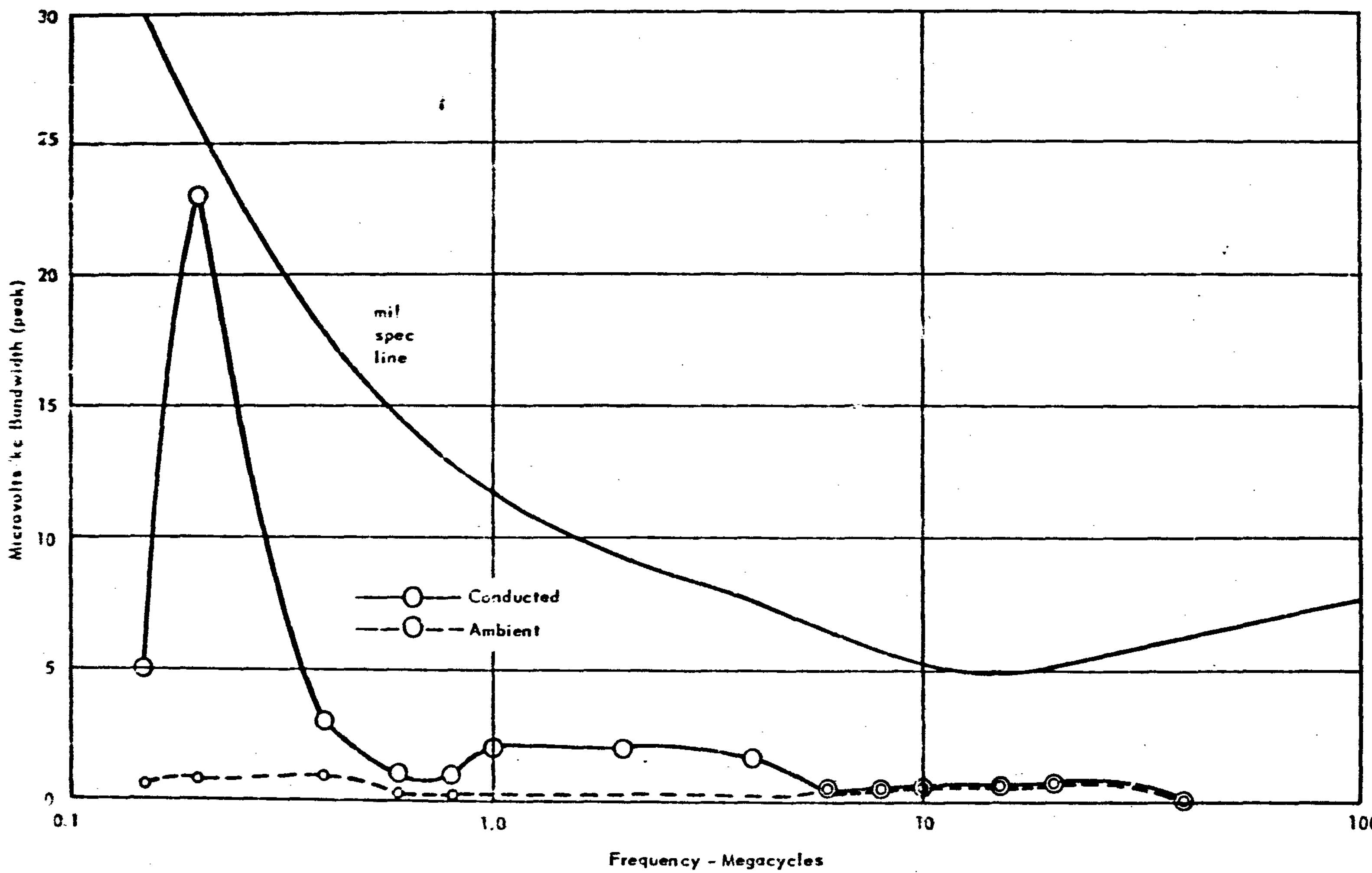

Figure 14. Fixture D, cold cathode industrial lamp, broadband conducted interference (peak).

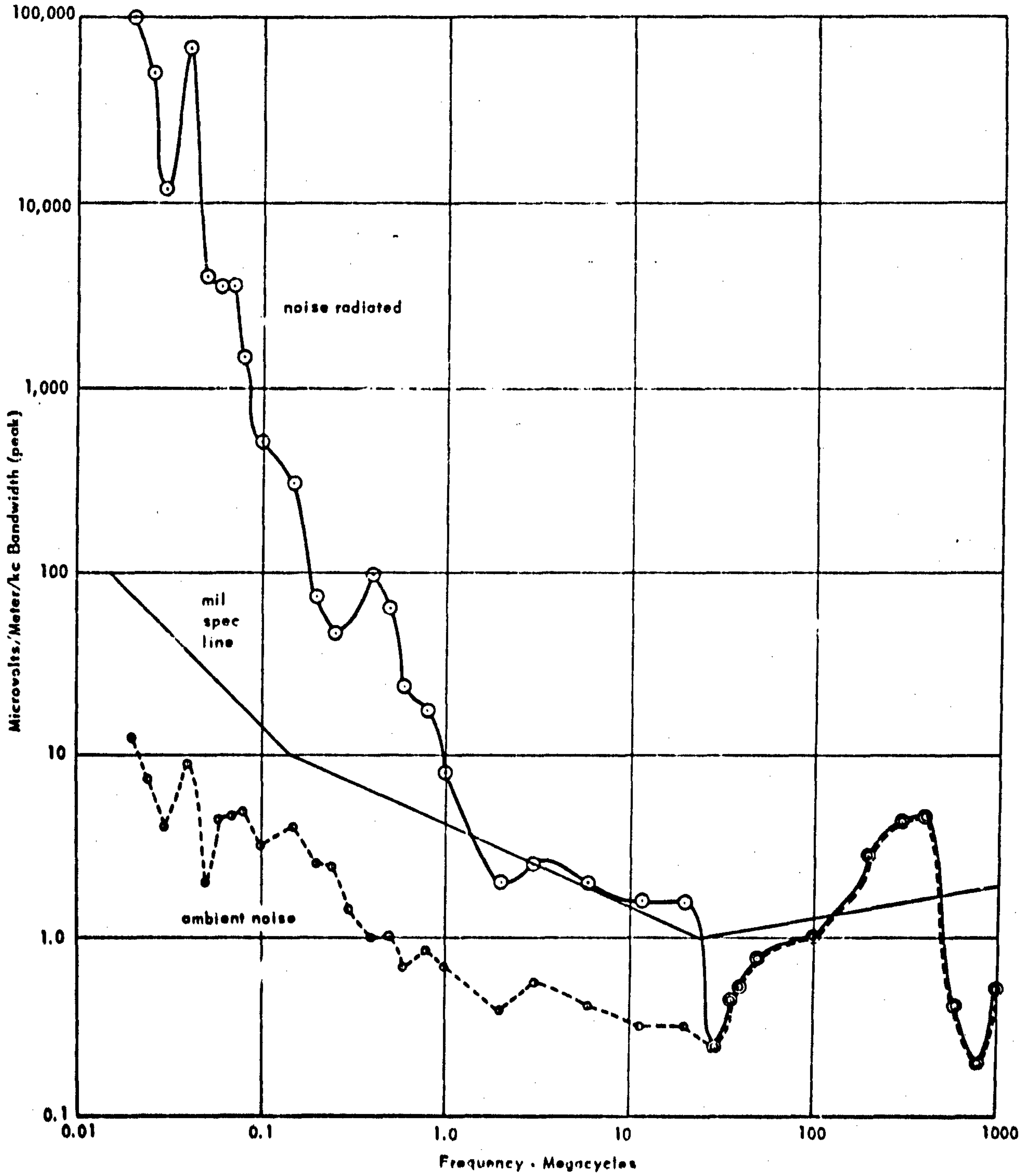

Figure 15. Fixture C, cold cathode desk lamp, broadband radiated interference (peak).

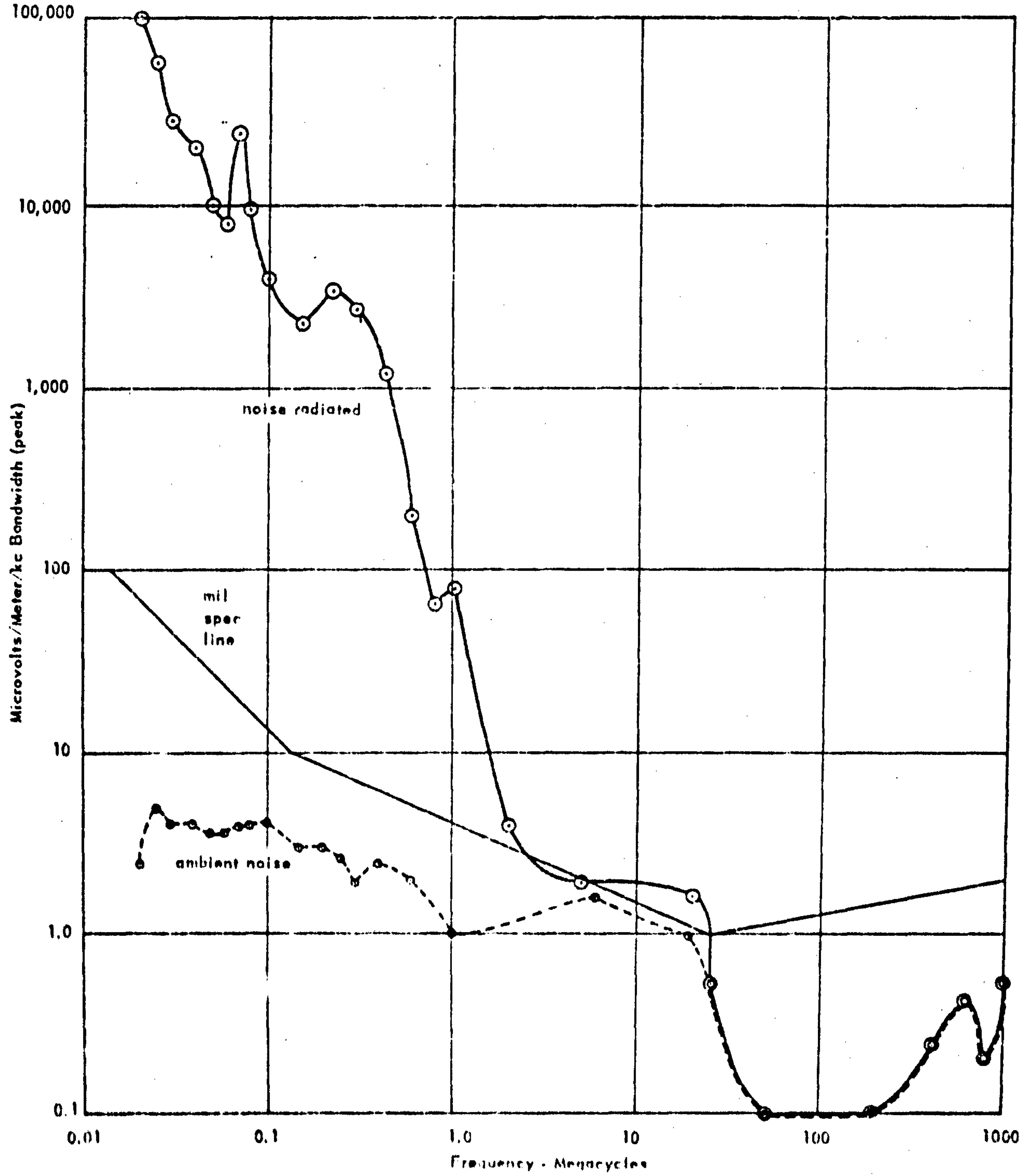

Figure 16. Fixture D, cold cathode industrial lamp, broadband radiated interference (peak).

DISTRIBUTION LIST

No. of Copies	SNDL Code	
10		Chief, Bureau of Yards and Docks
1	23A	Naval Forces Commanders (Taiwan Only)
2	39B	Construction Battalions
9	39D	Mobile Construction Battalions
3	39E	Amphibious Construction Battalions
2	39F	Construction Battalion Base Units
1	A2A	Chief of Naval Research - Only
2	A3	Chief of Naval Operations (Op-07, Op-04)
6	A5	Bureaus
2	B3	Colleges
2	E4	Laboratory ONR (Washington, D. C. only)
1	E16	Training Device Center
8	F9	Station - CNO (Boston; Key West; New Orleans; San Juan; Long Beach; San Diego; Treasure Island; and Rodman, C. Z. only)
5	F17	Communication Station (San Juan; San Francisco; Pearl Harbor; Adak, Alaska; and Guam only)
1	F21	Administration Command and Unit CNO (Saipan only)
1	F40	Communication Facility (Pt. Lyautey only)
1	F41	Security Station
2	F42	Radio Station (Oso and Cheltanham only)
1	F48	Security Group Activities (Winter Harbor only)
8	H3	Hospital (Chelsea; St. Albans, Portsmouth, Va; Beaufort; Great Lakes; San Diego; Oakland; and Camp Pendleton only)
1	H6	Medical Center
2	J1	Administration Command and Unit-BuPers (Great Lakes and San Diego only)
1	J3	U. S. Fleet Anti-Air Warfare Training Center (Virginia Beach only)
2	J4	Amphibious Bases
1	J19	Receiving Station (Brooklyn only)
1	J34	Station - BuPers (Washington, D. C. only)
1	J37	Training Center (Bainbridge only)
1	J46	Personnel Center
1	J48	Construction Training Unit
1	J60	School Academy
1	J65	School CEC Officers
1	J84	School Postgraduate
1	J90	School Supply Corps

Distribution List (Cont'd)

No. of copies	SNDL Code	
1	J95	School War College
11	L1	Shipyards
4	L7	Laboratory - BuShips (New London; Panama City; Carderock; and Annapolis only)
5	L26	Naval Facilities - BuShips (Antigua; Turks Island; Barbados; San Salvador; and Eleuthera only)
1	L30	Submarine Base (Groton, Conn. only)
2	L32	Naval Support Activities (London & Naples only)
2	L42	Fleet Activities - BuShips
4	M27	Supply Center
8	M28	Supply Depot (Except Guantanamo Bay; Subic Bay; and Yokosuku)
1	M61	Aviation Supply Office
12	N1	BuDocks Director, Overseas Division
28	N2	Public Works Offices
7	N5	Construction Battalion Center
5	N6	Construction Officer-in-Charge
1	N7	Construction Resident-Officer-in-Charge
12	N9	Public Works Center
1	N14	Housing Activity
2	R9	Recruit Depots
2	R10	Supply Installations (Albany and Barstow only)
1	R20	Marine Corps Schools, Quantico
3	R64	Marine Corps Base
1	R66	Marine Corps Camp Detachment (Tengan only)
7	W1A1	Air Station
34	W1A2	Air Station
9	W1B	Air Station Auxiliary
4	W1C	Air Facility (Phoenix; Monterey; Oppama; Naha; and Naples only)
3	W1E	Marine Corps Air Station (Except Quantico)
1	W1F	Marine Corps Auxiliary Air Station
8	W1H	Station - BuWeps (Except Rota)
1		Chief of Staff, U. S. Army, Chief of Research and Development, Department of the Army, Washington, D. C.
1		Office of the Chief of Engineers, Asst. Chief of Engineering for Civil Works, Department of the Army, Washington, D. C.
1		Chief of Engineers, Department of the Army, Attn: Engineering R & D Division, Washington, D. C.

Distribution List (Cont'd)

No. of copies	
1	WADD (WWAD - Library), Wright-Patterson AFB, Ohio
1	Deputy Chief of Staff, Development, Director of Research and Development, Department of the Air Force, Washington
1	President, Marine Corps Equipment Board, Marine Corps Schools, Quantico, Va.
1	Director, National Bureau of Standards, Department of Commerce, Connecticut Avenue, Washington, D. C.
10	Armed Services Technical Information Agency, Arlington Hall Station, Arlington, Va.
1	Deputy Chief of Staff, Research and Development Headquarters, U. S. Marine Corps
3	Headquarters, USAF, Directorate of Civil Engineering, Attn: AFOCE-ES, Washington, D. C.
2	Commander, Headquarters, Air Research and Development Command, Andrews Air Force Base, Washington, D. C.
2	Office of the Director, U. S. Coast and Geodetic Survey, Washington, D. C.
2	Library of Congress, Washington, D. C.
2	Director of Defense Research and Engineering, Department of Defense, Washington, D. C.
2	Director, Division of Plans and Policies, Headquarters, U. S. Marine Corps, Washington, D. C.
2	Director, Bureau of Reclamation, Washington, D. C.
2	Commanding Officer, U. S. Naval Construction Battalion Center, Attn: Technical Division, Code 141, Port Hueneme, Calif.
2	Commanding Officer, U. S. Naval Construction Battalion Center, Attn: Materiel Department, Code 142, Port Hueneme, Calif.
1	Commanding Officer (Patent Dept.), Office of Naval Research Branch Office, 1030 E. Green Street, Pasadena, Calif.
1	Commanding Officer, Yards and Docks Supply Office, U. S. Naval Construction Battalion Center, Port Hueneme, Calif.
1	Chief of Engineers, Attn: ENGCW-C, Washington, D. C.
1	Chief, Bureau of Ships, Attn: Chief of Research and Development Division, Navy Department, Washington, D. C.
1	Officer in Charge, U. S. Navy Unit, Rensselaer Polytechnic Institute, Troy, New York
1	Chief, Bureau of Medicine and Surgery, Attn: Research Division, Navy Department, Washington, D. C.
1	Director, Marine Physical Laboratory, U. S. Navy Electronics Laboratory, San Diego
1	Chief, Bureau of Naval Weapons, Attn: Research Division, Navy Department, Washington, D. C.
1	Commander, Pacific Missile Range, Attn: Technical Director, Point Mugu, Calif.
1	Commander, U. S. Naval Shipyard, Attn: Material Laboratory, Brooklyn, N. Y.
1	Commanding Officer, Naval Electronics Laboratory, Attn: Technical Director, San Diego
1	Commanding Officer, Signal Corps Engineering Labs, Fort Monmouth, N. J.
1	U. S. Army Electronic Proving Ground, Fort Huachuca, Ariz.
1	Armour Research Institute, Illinois Institute of Technology, Chicago, Ill.
1	The Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia

U. S. Naval Civil Engineering Laboratory.
Technical Report R-166.
EVALUATION OF INTERFERENCE SUPPRESSION OF FLUORESCENT LAMPS, by D. B. Clark.
25 p. illus. 6 Oct 61. UNCLASSIFIED

An evaluation of the interference characteristics of fluorescent lamps demonstrated that those which are completely enclosed electrically are free of interference. A hot-cathode instant-start fixture was found which proved to be 6 decibels below Navy specification limits. None of the cold-cathode lamps met specification limits.

1. Fluorescent lamps -- Interference suppression
I. Clark, D. B.
II. Y-F006-09-202

U. S. Naval Civil Engineering Laboratory.
Technical Report R-166.
EVALUATION OF INTERFERENCE SUPPRESSION OF FLUORESCENT LAMPS, by D. B. Clark.
25 p. illus. 6 Oct 61. UNCLASSIFIED

An evaluation of the interference characteristics of fluorescent lamps demonstrated that those which are completely enclosed electrically are free of interference. A hot-cathode instant-start fixture was found which proved to be 6 decibels below Navy specification limits. None of the cold-cathode lamps met specification limits.

1. Fluorescent lamps -- Interference suppression
I. Clark, D. B.
II. Y-F006-09-202

U. S. Naval Civil Engineering Laboratory.
Technical Report R-166.
EVALUATION OF INTERFERENCE SUPPRESSION OF FLUORESCENT LAMPS, by D. B. Clark.
25 p. illus. 6 Oct 61. UNCLASSIFIED

An evaluation of the interference characteristics of fluorescent lamps demonstrated that those which are completely enclosed electrically are free of interference. A hot-cathode instant-start fixture was found which proved to be 6 decibels below Navy specification limits. None of the cold-cathode lamps met specification limits.

1. Fluorescent lamps -- Interference suppression
I. Clark, D. B.
II. Y-F006-09-202

U. S. Naval Civil Engineering Laboratory.
Technical Report R-166.
EVALUATION OF INTERFERENCE SUPPRESSION OF FLUORESCENT LAMPS, by D. B. Clark.
25 p. illus. 6 Oct 61. UNCLASSIFIED

An evaluation of the interference characteristics of fluorescent lamps demonstrated that those which are completely enclosed electrically are free of interference. A hot-cathode instant-start fixture was found which proved to be 6 decibels below Navy specification limits. None of the cold-cathode lamps met specification limits.

1. Fluorescent lamps -- Interference suppression
I. Clark, D. B.
II. Y-F006-09-202